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ABSTRACT

This paper examines research on students' learning in small tutorial groups, highlighting: (1) cognitive processes elicited by small group discussion and their effects on achievement; and (2) the influence of tutors on student learning. The studies examined problem based learning (PBL) in small groups in high schools and universities. Researchers investigated whether: PBL activated students' prior knowledge; initial analysis of problems stimulated retrieval of knowledge acquired earlier; and prior knowledge facilitated understanding of new information. They noted the effect of prior knowledge activation on processing new information; contributions of group discussion to the effect of PBL; cognitive processing while involved in problem discussion; and evidence for constructive processes in small group tutorials. They also investigated the extent to which tutors should be subject matter experts, noting behaviors that characterized effective tutors. They examined research on: expert and non-expert staff tutors; staff and student tutors; reasons for inconclusive results of tutor expertise studies; differences in actual behavior between tutors; and theories of effective tutors. Results suggest that initial analysis of a problem mobilizes students' prior knowledge that is used to construct an initial representation of the processes responsible for the phenomena or events described in it. Students' construction of this initial theory facilitates the comprehension of problem-relevant new information. Social congruence, subject matter expertise, and the ability to be cognitively congruent with one's students are all crucial to effective tutoring. (Contains 30 references.) (SM)

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Processes that Shape Small-Group Tutorial Learning: A Review of Research

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Introduction

Problem-based learning as an educational approach gains more and more attention at all levels of education at the Netherlands. In the last decennium many schools in higher education, at the university level as well as at the level of higher professional training, have implemented problem-based learning (PBL) totally or partially in their curricula.[3]
Nowadays secondary education, high schools and schools which prepare students for professions at the middle level, become more and more interested in the way PBL organizes students' learning activities. Some schools are already trying to cary out PBL in parts of their curricula. Next year all Dutch high schools have to change drastically the last two years of their curriculum into the direction of a more student-centered educational program (An innovation started by the Ministry of Education in 1994). High schools have to develop a so-called 'Studyhouse', a learning environment in which students should gradually take more responsibility for their own learning. At the moment a lot of high schools are trying out several educational approaches which would help teachers to build a learning environment in which students will develop active, self-directed learning skills. Of course, many schools are interested in the educational concepts of PBL, questioning themselves whether PBL can be used as a method of learning useful for 16th and 17th year-old students.

Before discussing the processes that shape the learning of students in and outside small tutorial groups we briefly describe the main frame of the Maastricht process of the problem-based learning approach and its cognitive psychological backgrounds, see Figure 1.

-- insert Figure 1 somewhere here --

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[3] The ways by which students are prepared for university training in the Netherlands differs from Northern America. In principle, university training is open to all students passing secondary school final examiniations (A-level). There is no entrance examiniation, nor are other ways of selection employed. There is no preparatory college education. However, Dutch secondary education is generally concentrating more on academic subjects than American high schools. Therefore, university students in the Netherlands are younger than their colleagues in the USA and are relatively less well-equipped with self-directed learning skills.

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A problem, written by a team of teachers, aims to guide students towards certain subject matter. A problem usually decribes some phenomena or events that can be observed in daily live, but can also consist of a description of an important theoretical or practical issue (Schmidt, 1983). Problems are the starting point of students' learning process. Problems are presented to students for discussion in a small tutorial group, a group of ten students. Usually the students have to explain the phenomena or events presented to them in terms of underlying mechanisms, principles or processes. The students do not prepare themselves for the initial discussion of the problem. They come into the situation equipped only with their prior knowledge. While discussing a problem, the group employs a specific procedure which all students have been taught shortly after entering a problem-based curriculum. This procudure is called the 'Seven Jump' (Schmidt, 1983). The procedure consists of seven steps to be completed by a tutorial group to take maximal advantage of a problem. Table 1 shows an overview of these steps and of the most important cognitive processes behind various steps.

-- insert Table 1 somewhere here --

All learning in a problem-based curriculum *starts with a problem*. The attemps made by the students to make sense of the phenomena or events described in the problem, can be considered *a process of theory construction*. While discussing the problem, students engage in formulating a theory that may explain the phenomena or events presented to them. As students are not supposed to prepare themselves prior to encountering the problem in the tutorial group they construct this theory based on prior knowledge, common sense and logical thinking. Prior knowledge mobilized by one participant tends to activate previously more-difficult accessible knowledge in another participant. Not only *activation of prior knowledge* takes place, learners also begin to elaborate on what they know and try to build bridges between their knowledge and the phenomena described in the particular problem. Typically, in a small-group session much *elaboration* based on what the participants already know can be observed. Their attempt to account for the problem may lead to a first reconstruction of what they know; the emergence of a new problem-oriented knowledge structure. Since different students tend to know or think somewhat different things, theory construction becomes *a collaborative effort*, that may lead to new insights, not present in the participants before the analysis of the problem began.
However, in the course of the discussion, of course, questions come up which cannot be answered by any of the participants in the group, or several alternatives are proposed between which the students are unable to choose, or students conclude that they only have a vague idea of the explanantion of a phenomena or event. A gap between what is known and understood and what is not understood will be experienced. This perceived cleft induces an *intrinsic motivation to learn*. The isues in need of further clarification are taken as cues for *self-directed learning activities* and students spend considerable time with various resources sorting out these issues. Upon returning in the tutorial group, after two days of study, the new knowledge acquired is discussed and integrated by applying the information to the problem at hand to check whether the explanantory theory constructed can better deal with the phenomena presented, than the original ideas produced during the previous session. A tutorial group is supported by a staff member, known as *the 'tutor'*. The role of the tutor is to facilitate students learning process and to stimulate students to collaborate in an effective way.

The basic model of the various elements of PBL on learning outcomes such as knowledge and increased interest insubject-matter is shown in Figure 2, in which input, throughput and output variables of PBL are represented.

insert Figure 2 somewhere here --

In this presentation some research will be presented around students' learning in the small tutorial group. This research, done by the Maastricht Educational Research Group of the University of Maastricht, has been focused on four topics: (1) the quality of problems, (2) cognitive processes elecited by small group discussion and their effects on achievement, (3) motivational influences, and (4) the influence of the tutor on student learning. Studies have been carried out in high schools as well as in schools in higher education.[4] In this presentation we discuss some studies out of the second and fourth topic.

Cognitive processes elecited by small group discussion and their effects on achievement

The questions are:

1. Does PBL activate students' prior knowledge?
2. Does the initial analysis of a problem stimulate the retrieval of knowledge acquired earlier?
3. Does this prior knowledge facilitates the understanding of new information?

ad 1. *Effects of prior knowledge activation on the processing of new information*

Schmidt and his colleagues (1989) presented a problem (the blood-cell) to fourtheen-year old high school students that never had studied the subject concerned.

One group of students were ask to discuss this problem, in small-tutorial groups, on the basis of their prior knowledge; another group of students were asked to discuss, in small-tutorial groups, a neutral topic.

Subsequently to the discussion, a six page text about the topic osmosis was distributed to both groups of students. After studying this text students were asked to fill out a test.

The the group that discussed the blood-cell problem prior to reading the text rememberd significantly more about the text than the group that had studied an unrelated topic.

These findings indicate that activation of prior knowledge through problem analysis in a small group definitely facilitates understanding and remembering new information, even if that prior knowledge is only to a small extent relevant to understanding the problem - and sometimes even incorrect.

ad 2. *Contribution of group discussion to the effect of problem-based learning.*

Of course, prior knowledge activation can be performed in several ways, e.g. by giving students questions or by asking to write down everything they remember about a topic. Does group discussion contribute more? De Grave, Schmidt, Beliën, Moust, De Volder and Kerkhofs (1984) have compared effects of problem-analysis in a small group with individual problem analysis and direct prompting of knowledge about osmosis. They discovered that small-group analysis had a larger positive effect on remembering a text than individual problem analysis. Simply prompting already available knowledge relatively had the smallest effect. The investigators concluded that the confrontation with a relevant problem and small-group discussion of that problem each have an independent facilitating effect on prior knowledge relative to direct prompting of prior knowledge. Group discussion had, in particular, a considerable effect, suggesting that elaboration on prior knowledge and learning from each other, even before new information is acquired, are potent means to facilitate understanding of problem-relevant information.

Ad 3a. *Cognitive processing while involved in problem discussion*

Students are, of course, not always involved to the same amount of overt verbalization of

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[4] A more elaborated description of this research will be published in: Evensen, D. H., & Hmelo, C. E. (Eds.), (In preparation). Problem-based learning: A Research Perspective on Learning Interactions. Hillsdale: NJ: Lawrence Erlbaum.

information in a small-group discussion. What happens to those who participate less actively in the tutorial group? Do students who elaborate less verbally - the silent students - learn less? Research by Moust, Schmidt, De Volder, Beliën and De Grave (1986) demonstrated that the quantity of one's contribution to the discussion and its quality were unrelated to achievement. This led the researchers to the conclusion that subjects not - or less participating in the discussion elaborate as much as those who do participate, without verbalizing their elaborations to the same extent as the latter. The more silent students were involved in what they called 'covert elaboration.' These students are elaborating without sharing their conclusions with their fellow-students. According to these authors it would otherwise be hard to understand how these students would profit from the experience.

ad 3b. *Evidence for constructive processes in small group tutorials*
In a recent study, De Grave, Boshuizen and Schmidt (1996) investigated the ongoing cognitive and metacognitive processes during the phase of problem-analysis, by analyzing the verbal communication among group members and their thinking processes. Thinking processes were tapped by means of a stimulated recall procedure. Directly after a tutorial session, each participant individually saw a videotape of the session and was requested to stop the tape whenever he or she would recall particular thoughts that came up during discussion. The investigators analyzed the verbatim transcripts of both the verbal interaction in the tutorial group and the recall protocols to study to what extent the ongoing processes can be described as theory construction, and whether there is evidence of conceptual change in small group tutorials. The authors discovered that the verbal protocols were dominated by attempts at theory building, causal reasoning and hypothesis testing. Considerable time was also spent on what the authors describe as data exploration --finding out what the significance is of the various cues in the problem--, and problem definition. Less attention was given to procedures and meta-reasoning. By contrast, the thinking of the students especially reflected meta-reasoning. Students evaluate the appropriateness of their prior knowledge, reflect on the learning process, and on strategies of thinking. It seems that, while thinking, students prepare their utterances and assess to what extent they are relevant to the task at hand. They also pay thought to the process of collaboration, although this category hardly shows up in the actual verbal interaction. This indicates that students are sensitive to the way the group collaborates, and take their own contributions in this respect into account. Theory construction and evaluation are also prevalent in the stimulated recall protocols. Interestingly, the investigators found 'bursts' of theory construction, alternated by data exploration. It seems that ideas are proposed in a cyclical fashion that continues during the whole session. Even in the last three minutes of the 20-minutes meeting, new ideas were proposed. In addition, the patterns of verbal interaction and individual thought are rather similar, thoughts being both a response to what is said and a precursor. Finally, the authors present evidence for conceptual change as a result of initial problem discussion. Students evaluate what is proposed by other students and are influenced by the arguments exchanged. This is a somewhat surprising finding, because it was expected that conceptual changes would result largely from reading the literature.

The influence of the tutor on student learning

As said above, the tutor has to facilitate students' learning process and to stimulate their co-operation. the contributions of a tutor are geared towards challenging the students to clarify their own ideas, to incite students to elaborate upon the subject matter, to question ideas, to look for inconsistencies, and to consider alternatives. By doing so, he or she helps the students to organize their knowledge, to resolve their misconceptions, and to discover not well understood concepts. to do so a tutor should be capable of understanding the frame of mind of the students while discussing the problem and the subject-matter it refers to. A tutor should be able to imagine how people think if they only have a limited knowledge of a subject or field. to stimulate students'

collaboration in a tutorial group, a tutor should also be able to manage interpersonal dynamics, be sensitive to group development processes and handle interpersonal conflicts. As students are offered subjects in an interdiciplinary way, and tutors are rarely content experts in all disciplines studied during problem-based courses, the question "What does the tutor contribute to the learning of students in a tutorial group?"
Questions we will discuss here are:
1. To what extent should tutors be subject-matter experts?
2. Which behavoirs characterize an effective tutor?

ad 1.
The question about the necessary level of a tutors' expertise has dominated, from the onset, the literature on the role of the tutor in PBL (Barrows and Tamblyn, 1980). Barrows (1988) for example states that ideally tutorial groups are best guided by experts: "there is no questions that the ideal situation is for the tutor to be an expert, both as tutor and in the discipline being studied by the students" but "if this is not possible, the next best tutor is the teacher who is good at being a tutor, .., though not an expert in the discipline being studied. The worth thing to happen is confronting students with a tutor "who is an expert in the area of study, but a weak tutor".
However, teachers who are an expert in the area of study, and possess competent facilitating tutorial skills, are at least in higher education in the Netherlands the exception rather than the rule. The question then becomes: To what extent can students do with non-subject-matter tutors, and even with non-expert poor tutors?
Although most advocates of problem-based learning emphasize the importance of the tutor role for students' learning in tutorial groups, until recently, there was almost no empirical data available concerning the question of tutors' expertise. In this contribution we will present data on this topic collected in various academic programs at Maastricht University. First, we will concentrate on findings regarding effects of expert or non-expert staff tutors on their students' learning. Next, we will review research comparing tutorial groups guided by either staff or student tutors. In a subsequent section we will attempt to explain differences in outcomes between the various studies. Finally, we will make an effort to summarize the various findings in a comprehensive theory of tutor functioning and present data in support of that theory.

Research comparing expert and non-expert staff tutors
In a study carried out at the medical school Swanson, Stalenhoef-Halling and Van der Vleuten (1990) investigated effects of expertise of 230 tutors on the performances of students, using end-of-course tests as the dependent measure. Since the particular curriculum integrated biomedical, clinical, and psychosocial aspects of medicine in each course, the investigators subdivided each end-of-course test according to these three categories and studied the impacts of tutors' professional backgrounds on student performances on the resulting subtests. No effect of expertise was found.
In an extensive research effort, Schmidt, Van der Arend, Moust, Kokx, and Boon (1993) investigated the effects of tutor's subject-matter expertise on students' levels of academic achievement in the problem-based health sciences curriculum of Maastricht University in Maastricht. Data were analyzed from 336 staff-led tutorial groups involving students participants in seven four-year undergraduate programs. The results showed that students guided by subject-matter experts achieved somewhat better than students guided by non-experts tutors. The effect of subject-matter expertise on achievement was strongest in the first curriculum year.
Another study by Schmidt (1994) also showed that students guided by expert tutors performed significantly better than students guided by non-expert tutors. Data were analyzed from 1,800 Maastricht University health sciences students who participated in tutorial groups led by content-expert staff tutors, non-expert staff tutors, or student tutors. The main effect of expertise

level on achievement was statistically significant, showing that the higher the level of subject-matter expertise of the tutor, the better the students' achievement.

Research comparing staff and student tutors

Most research in comparing tutorial groups guided by staff with those guided by student tutors has almost exclusively been conducted at Maastricht University. Responsible for this phenomenon is that in most of these programs a great number of students enter every year; e.g., approximately 1500 students apply to the health sciences, law, and economics programs every year. In response to the influx of these large numbers of students, the various faculty boards decided to investigate whether it would be possible to employ students to perform the tutor role. In all schools, the student tutors hired were advanced undergraduate students. For most programs there were no strict criteria for selecting student tutors. Students had to show a reasonable level of achievement generally and a positive attitude towards problem-based learning. Before students were entitled to tutor they had to participate in a workshop on tutoring skills. In the studies reviewed below, the student tutors can be considered relatively non-expert as compared with the academic staff.

A study of law students by Moust, De Volder, and Nuy (1989), involving ten student tutors and ten staff tutors in a first-year course, revealed a significant difference supporting the hypothesis that tutors' subject-matter expertise indeed facilitates student performance. A follow-up study in two other courses by Moust (1993), however, failed to replicate the findings of the previous study. No differences were found between student- and staff-guided groups.

Schmidt, Van der Arend, Kokx & Boon (1994) studied effects of students versus staff tutoring on student learning in the health sciences program. Academic achievement of 334 tutorial groups guided by staff tutors was compared with achievement of 400 groups guided by student tutors. Overall, students guided by a staff tutor achieved somewhat better. In terms of practical significance, the difference was, however, fairly small.

Research on effects other than is rather scarce. Moust (1993) found differences in time spent on self-directed study in one course. Students guided by student tutors spent significantly less time on self-directed study than students guided by staff tutors.

In summary, the results of the studies comparing expert staff tutors and non-expert staff tutors as well as the research comparing staff and student tutors reviewed here are generally inconclusive. This outcome is in line with research on this topic conducted in problem-based curricula elsewhere (Des Marchais & Black, 1991; Davis, Nairn, Paine, Anderson, & Oh, 1992; Davis, Oh, Anderson, Gruppen, & Nairn, 1994; Eagle, Harasym, & Mandir, 1992; Gruppen, Traber, Woolliscroft & Davis, 1992; Wilkerson, Hafler & Liu, 1991; Silver & Wilkerson, 1991). Of the four studies comparing academic achievement levels of students guided by staff tutors of different levels of subject-matter expertise, two (Schmidt, et al. 1993; Schmidt, 1994) demonstrated an effect in favor of the experts staff tutors. One study (Swanson, et al. 1990) showed no differences in achievement. Of the four studies comparing staff tutoring with student tutoring, one (Schmidt, et al. 1994) demonstrated significant differences favoring students guided by staff students, one study (Moust, et al. 1989) showed mixed outcomes and two studies (De Grave, et al. 1990; Moust, 1993) did not reveal any differences at all.

Reasons for inconclusive results of the tutor expertise studies

The question, of course, is how these contradictory results may be explained. Several reasons have been proposed in the literature (Schmidt, et al. 1993; Moust, 1993, Schmidt, 1994).

The first reason may be related to the definition of what actually constitutes subject-matter expertise in small-group tutoring. In some studies an extremely stringent definition of what constitutes a content-expert was applied: Expert tutors were those staff members who had an active research interest in the specific topic studied by the students. Non-experts included all non-specialists in the field concerned (Davis, et al., 1992; 1994). Other studies (in the domain of

medicine) divided the tutors in three broad subject-matter categories: biomedicine, clinical medicine, and social sciences staff. Another group of studies defined expertise uniquely in relation to the course's content. Experts were those who had received training in the area covered by the course (e.g. a biochemist in a course about nutrition), non-experts included all academic staff who had expertise only partially related to the topic at hand (e.g., general practioner, epidemiologist, sociologist). In the studies comparing staff with student tutoring, on the other hand, content expertise was considered equivalent to the level of training of the tutor and not so much to his or her specific knowledge (all academic staff were considered expert). This may imply that some staff tutors employed in these studies were not really content experts in the stricter sense of the word. In his study carried out in two consecutive courses, Moust (1993), did not find any differences in achievement between student-led groups and staff-led groups. However, after removing a number of non-expert staff from his analyses, Moust demonstrated - a posteriori - that subject-matter expertise indeed made a difference in terms of student achievement.

A second reason for the inconclusiveness of the findings may be the magnitudes of the samples studied. Most studies examined effects of subject-matter expertise in one single course (De Grave, et al. 1990; Moust, et al. 1989). Only two studies included an entire year or an entire curriculum (Swanson, et al. 1990; Schmidt, et al. 1993). Even if the subject-matter expertise of the tutor makes a difference, its influence is bound to be small. Students spend relatively little time with their tutor and during these encounters, the verbal contributions of the tutor are mostly limited. Reliable effects, if any, will show up only when sufficient numbers of tutorial groups are included in the analysis, that is, if the power of the statistical test applied is sufficiently great. Studies employing large samples, however, also show contrasting results.

The extent to which students are exposed to problem-based learning may also be a factor. It is often observed that students who have little or no experience with problem-based learning rely more heavily on their tutors as sources of guidance and information. If these tutors are familiar with the subject-matter to be mastered, this may make a difference. This observation may explain why the positive findings reported were largely confined to first-year courses, or to courses in which students encountered problem-based learning for the first time. Novice students may lean more on their tutors' expertise than do students in later years.

A fourth explanation - in agreement with the third - has been proposed by Schmidt (1994). Based on his earlier studies (in which he found effects of tutor expertise mainly in those cases in which students were largely novices to the domain), he conjectured that students in a problem-based curriculum need a minimum level of structure if any useful learning is to take place. This structure can be provided either internally, –through the prior knowledge that students already have with regard to the topic at hand– or externally, –through the structure provided by the learning materials. If these kinds of structures lack for some reason, students will seek for structure provided by their tutor. Only under these conditions, a subject-matter-expert tutor may have a positive impact on his students' learning. Or to put it negatively: Only under these circumstances students with a non-expert tutor are handicapped as compared to their peers. In a study testing these hypotheses, he found that: (a) Tutor expertise particularly influenced student achievement when the students had limited prior knowledge. When the level of prior knowledge was high, it was less important whether the tutor was a subject-matter expert or not. Students are then able to organize the new information themselves. (b) The impact of tutors' expertise was also greater when the structure of the course materials was low, suggesting that tutor expertise indeed compensates for lack of structure in the curriculum. Offering sufficient structure (e.g. through proper introductions, high-quality cases, and clear references to the literature) may help students to study on their own. And (c) the impact of tutors' level of expertise was greatest in courses which were both poorly structured and introduced topics unfamiliar to students. These findings suggest that indeed the tutor can be considered a last resort device. Student would seek guidance from their tutor mainly when everything else fails.

In conditions were materials are sufficiently structured and prior knowledge is sufficient, the subject-matter expertise of the tutor seems to play a limited role.

ad 2. Differences in actual behavior between tutors

A final reason for the inconclusiveness of the findings in the tutor subject-matter expertise studies may be that in some studies the experts did not behave differently from the non-experts, while in other studies the experts behaved differently. Schmidt, et al. (1993), for instance, found clear differences in behavior (as observed by students) between expert and non-expert tutors in relationship to students' achievement and study effort. Subject-matter experts displayed a deeper understanding of the objectives of the particular course, appeared to be more knowledgeable about the subjects to be mastered by the students, and used their subject-matter knowledge more frequently in order to help the students. In addition, their contributions in this respect were rated more relevant. The non-expert tutors, on the other hand, evaluated the group' functioning more often. Schmidt et al. concluded that the data indicate that subject-matter expertise is really what counts in small-group tutoring: subject-matter experts display more content-related behaviors while tutoring, resulting in better achievement and greater effort by their students. However, the process-facilitation behaviors are not irrelevant. "One of the more intriguing results of the present study is that process-facilitation behaviors such as asking questions and evaluating the group's progress are causally related to achievement in much the same way as subject-matter-related behaviors. An effective tutor appears to be someone who uses his or her subject-matter knowledge and at the same time is able to ask stimulating questions" (p. 790).

Schmidt and his colleagues (1993) also studied differences in behavior between student and staff tutors. The investigators found that staff tutors made a more extensive use of their subject-matter knowledge than student tutors. Detailed inspection of the data, however, showed that student tutors are rated higher in this respect in the first year of study, whereas staff tutors get higher ratings in the three subsequent years. The same phenomenon was also observed in the data concerning 'the relevance of the tutor's contributions' and 'asking stimulating questions.'

Moust (1993) and Moust & Schmidt (1994) studied differences in behavior of staff and student tutors in two subsequent courses of the first year curriculum of the law school. Based on interviews with both students and their tutors, the investigators distinguished between two main components of tutor functioning: the way a tutor handles the knowledge students must acquire (the subject-matter-input component) and the way a tutor establishes a personal relationship with the members of a tutorial group. Each component was assumed to have several sub-components. The subject-matter-input component contained the sub-components 'use of expertise': To what extent does a tutor use his or her subject-matter expertise to help students; 'cognitive congruence': To what extent is a tutor able to understand and to express him or herself at the students' level of knowledge (e.g. the ability to express oneself in the language of the students, using the concepts they use and explaining things in ways easily grasped by the students), and 'assessment orientation': To what extent does a tutor stress the importance of the end-of-course-test to direct the students' learning. The process-facilitation component was subdivided in the sub-components 'use of authority': To what extent does a tutor exercise his or her power to direct students' activities in the group; 'role congruence': To what extent is a tutor able to show empathy with and relate to students' life experiences (e.g. the willingness of the tutor to be a "student among the students", that is, to seek an informal relationship with the students and display an attitude of personal interest and caring), and 'focus on co-operation': To what extent is a tutor interested in students' co-operation in the tutorial group. The results showed that as far as the subject-matter-input component was concerned, staff tutors proved to use their expertise more frequently; student tutors, however, disposed significantly more 'cognitively congruent behavior' in a tutorial group (both courses showed significant differences in these respects). Student tutors were better at understanding the nature of the cognitive problems students faced in attempting to master the subject-matter. In addition, the investigators found

that student tutors referred more often to the end-of-course test than staff tutors to direct students' activities in the small-group tutorials. As for the process-facilitation component, the researchers also found contrasts between staff and student tutors. Staff tutors showed more authority in both courses, while student tutors behaved more role congruent; they were more interested in students' daily lives and study experiences and their personalities. As for attention to group co-operation, no differences appeared in groups led by a staff or student tutor. The findings leave one with the impression that student tutors better understand the nature of the intellectual problems first-year students face in the comprehension of the subject-matter as well as the demands that an university education poses upon them.

A theory of the effective tutor

Based on the findings reviewed here, in particular the differences in behaviors between expert, non-expert, and student tutors, Moust (1993) and Schmidt and Moust (1995) have proposed a theory of tutor performance. The investigators framed their ideas in the context of the theory of problem-based learning proposed by Schmidt and Gijselaers (1990).

A key concept in their theory of tutor performance is the concept of 'cognitive congruence.' As defined above cognitive congruence is a tutors' ability to understand and to express him or herself at the students' level of knowledge. To do this a tutor has to express oneself in the language of the students, using the concepts they use and explaining things in ways easily grasped by the students. If a tutor is not able to frame his of her contributions in a language that is adapted to the level of students' understanding of the subject matter studied, these contributions will go unnoticed. In addition, cognitive congruence assumes sensitivity of the tutor concerning the difficulties that students may come across while dealing with a problem or with the subject-matter relevant to that problem. A tutor should know when to intervene and what to offer: asking for clarification, suggesting a counterexample or providing some brief explanation. Cognitive congruence is a necessary condition for tutors to be effective. According to Moust (1993), a tutor can only be effective in this respect if he or she has relevant subject-matter knowledge and, in addition, has an authentic interest in his or her students' lives and their learning. Without appropriate subject-matter knowledge it will be difficult to follow the students' line of reasoning or actively contribute to it. And without a genuine and personal interest in the students and their learning there would not be a tempting reason to help them carrying out their task, nor would their be a particular urge to understand the nature of the difficulties students meet with while learning based on problems. Therefore, both subject-matter expertise and interpersonal qualities are necessary conditions for cognitive congruence to occur. Figure 3 summarizes the Schmidt and Moust position on tutor behavior and its effects on students.

-- insert Figure 3 somewhere here --

The figure can be read as follows: The more socially congruent the tutor is, and the more he uses his subject-matter knowledge, the more cognitively congruent he will be. Higher levels of cognitive congruence cause the tutorial group to function better, which expresses itself in more intrinsic interest in subject matter displayed by the students, extended self-study time, and higher achievement.

Research to test this theory of the effective tutor was done by Schmidt and Moust (1995) in Maastricht University's health sciences curriculum. To that end, data from 524 tutorial groups and their 261 tutors were studied. Students were asked to respond to items in a program evaluation questionnaire, in which the functioning of the tutor was an element, at the end of each course. The data were analyzed using a structural equations modelling approach (Bentler, 1989)

The authors' findings indicate that, however, the model tested represents a reasonable first

approximation of the structure underlying the data, the Moust (1993) model of effective tutor behavior does not adequately represent the data. However, the Moust model as proposed only allows one-to-one relations. This may be an unnecessary restriction, because there is no compelling theoretical reason why, for instance, social congruence of the tutor could not influence the quality of tutorial functioning directly, in addition to an indirect influence via cognitive congruence. Assuming that social congruence not only contributes to higher levels of cognitive congruence in the tutor, but also may have a direct positive impact on the way the group members interact with each other, a direct path would be appropriate. In addition, one could assume that the use of expertise by the tutor would not only be indirectly (through cognitive congruence and group functioning), but also directly affect the amount of time spent by students, or achievement, etc.

The investigators tested some of these alternatives and found that with a number of adaptations of the original model an excellent fit of the data could be established. The less restrictive model is displayed as Figure 4. For this embellished model of the effective tutor, ^{2} was equal to 15.36, df = 11, and p = .17. In addition, CFI = .99, and RMSR < .07.

– insert Figure 4 somewhere here –

These findings complicate, but do not contradict Moust's (1993) original assumptions. Both social congruence and expertise use appear to be important constructs, because they do not only affect cognitive congruence – as was hypothesized by Moust– but also influence other variables in the model. Social congruence does not only help the tutor being more cognitively congruent with his or her students, but also seems to facilitate group performance in a more direct way. Observations of small-group sessions have indeed documented immediate effects of tutoring style on the nature of student interactions (see e.g., Silver and Wilkerson, 1991), the more informal tutoring leading to higher levels of participation. In addition, students almost invariably report that they feel more free to contribute if a tutor displays an interest in what they do (Moust, 1993). Intriguing is the slightly negative influence of expertise on self-study time, suggesting that the more the tutor contributes to the discussion using his own subject-matter knowledge, the less time students spend on self-directed learning. Finally, the effect of the tutor's subject-matter expertise on achievement has been demonstrated.

So, effective tutoring in the context of problem-based learning seems to imply three distinct, though interrelated, qualities: the possession of a suitable knowledge base with regard to the topic under study, a willingness to become involved with students in an authentic way, and the skill to express oneself in a language understood by students. This theory of the effective tutor merges two different perspectives prevalent in the literature. One perspective emphasizes the personal qualities of the tutor; his or her ability to communicate with students in an informal way, coupled with an empathic attitude that enables them to encourage student learning by creating an atmosphere in which open exchange of ideas is facilitated. The other stresses the tutor's subject-matter knowledge as a determinant for learning.

Conclusion

Understanding how problem-based learning works, is only in its preliminary stages. The reader may have noticed that most research cited has been conducted in the last decennium. This implies that only recently, researchers have begun to gain an understanding of what happens to the learner in problem-based curricula. It seems to us that four issues have been resolved fairly satisfactorily. First, in a number of studies it has been demonstrated that the initial analysis of a problem mobilizes prior knowledge among students that is used to construct an initial representation of the processes responsible for the phenomena or events described in it. We have chosen to assign to these collaborative cognitive processes the label of theory construction;

students built a theory based on whatever they already know, suspect and think about the problem. Second, it has been demonstrated that the construction of this initial theory facilitates the comprehension of problem-relevant new information, suggesting that problem-based learning fosters a kind of learning that cannot be observed in more conventional set-ups. These findings are mainly based on the so-called 'red-blood-cell studies' conducted by Schmidt and his associates in the 80's. These studies were conducted in carefully controlled experiments somewhat remote from actual educational reality. Recently, however, De Grave (1997) has exactly replicated these findings in a medical curriculum, using actual curricular materials. Third, we know now quite a lot about the behaviors of tutors that tend to be effective in guiding their students. Social congruence, subject-matter expertise, and the ability to be cognitively congruent with one's students all seem to be crucial to effective tutoring. And fourth, we seem to have gained an understanding of the conditions under which tutors are most effective. If insufficient structure is provided by the learning environment and if students' prior knowledge of the subject to be mastered is limited, a knowledgeable, socially, and cognitively congruent tutor would tend to be most beneficial.

An area that deserves further study is what makes a problem useful. We know that good-quality problems are important (Gijselaers & Schmidt, 1990), but we do not really know what constitutes a good problem. Preliminary studies into this area have produced disappointing results (e.g., Kokx & Schmidt, 1990), in the sense that it proves difficult to distinguish between good and poor problems based on textual characteristics alone. It seems that quality of a problem can only be decided upon in the context of a particular course, taking into account the prior knowledge of the students. Further research is recommended here.

A second area deserving attention is what exactly students do while engaged in self-directed learning activities. We have only limited knowledge on the factors that influence what students do given a set of learning goals, and what we know about this, leads to the conclusion that there is no straightforward relationship between what is agreed upon during initial problem analysis in the tutorial group, and what students do subsequently.

A third area of concern has to do with long-term effects of problem-based learning. Some studies suggest that students in a problem-based curriculum learn less, but remember more in the long run. This is an intriguing finding, that should be elaborated upon

Working in small collaborative groups becomes more and more a normal educational approach in schools (Sharan, 1990; Hertz-Lazarowitz & Miller, 1992). With respect to the implementation of PBL at other levels of education as higher education, e.g. in high schools, our research indicates that learning with problems in small co-operative groups seems to foster students' cognitive learning processes and motivation. PBL is a collaborative form of learning in which students construct actively coherent mental models of knowledge rather than simple processing subject-matter. It offers students also a form of contextuel learning, because principles, ideas and mechanisms are not studied in abstract, but in the context of a concrete situation that can be recognized as relevant and interesting. As PBL does not need to be offered in a multidiciplinary way, teachers in high schools are able to guide students working on a specific subject matter. PBL as an educational approach could be useful to help high school students to become self-directed learners which are able to study more actively and independently.

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Table 1. The main frame of the process of problem-based learning

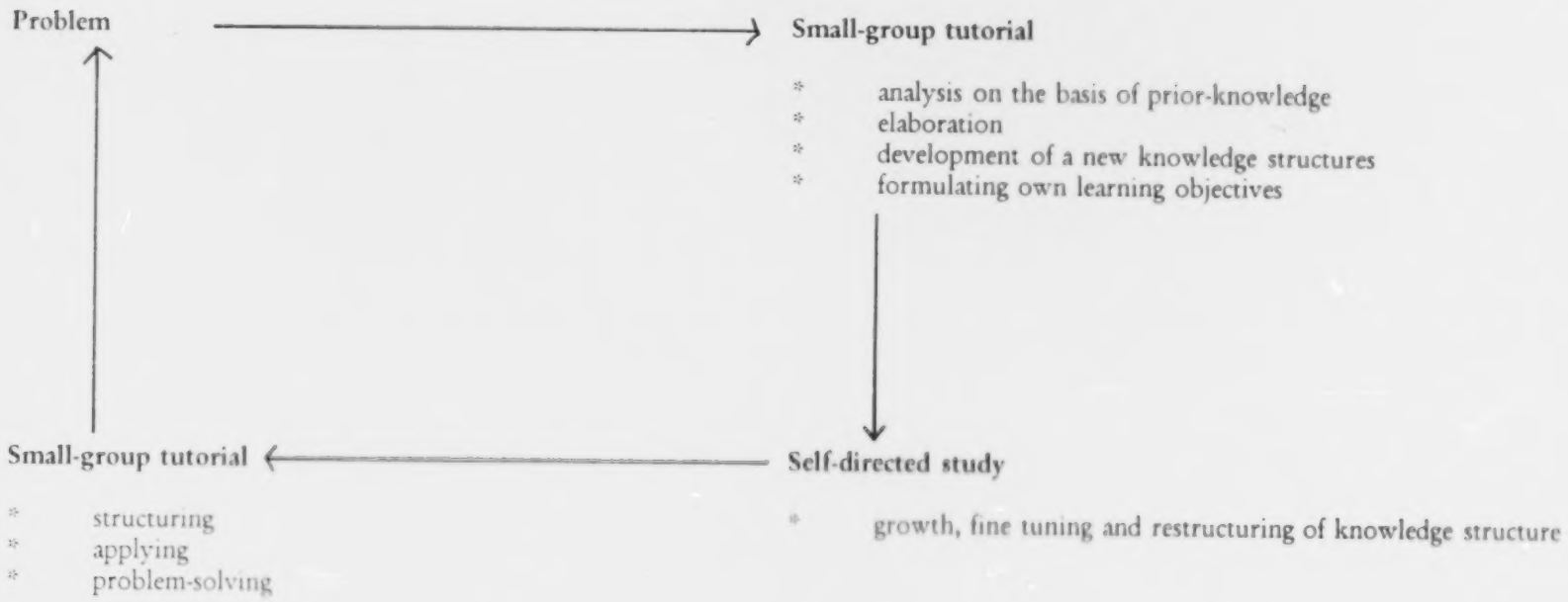

Figure 1. *The "Seven Jump"*

1.	Clarify unknown terms and concepts in the problem description.	
2.	Define the problem(s). List the phenomena or events to be explained.	
3.	Analyse the problem(s). Step 1. Brainstorm. Try to produce as many different explanations for the phenomena as you think of. Use prior knowledge and common sense.	* Activation of prior knowledge * Elaboration * (Re)structuring of information * Organisation of information * Intrinsic motivation
4.	Analyse the problem(s). Step 2. Discuss. Critize the explanations proposed and try to produce a coherent description of the processes that, according to what you think, underlie the phenomena or events.	
5.	Formulate learning issues for self-directed learning.	
6.	Fill the gaps in your knowledge through self-study.	
7.	Share your findings with your group and try to integrate the knowledge acquired into a comprehensive explanation for the phenomena or events. Check whether you know enough now.	* (Re)structuring * Applying * Problem-solving

Figure 2. *Theoretical model of problem-based learning (Schmidt & Gijselaers, 1990)*

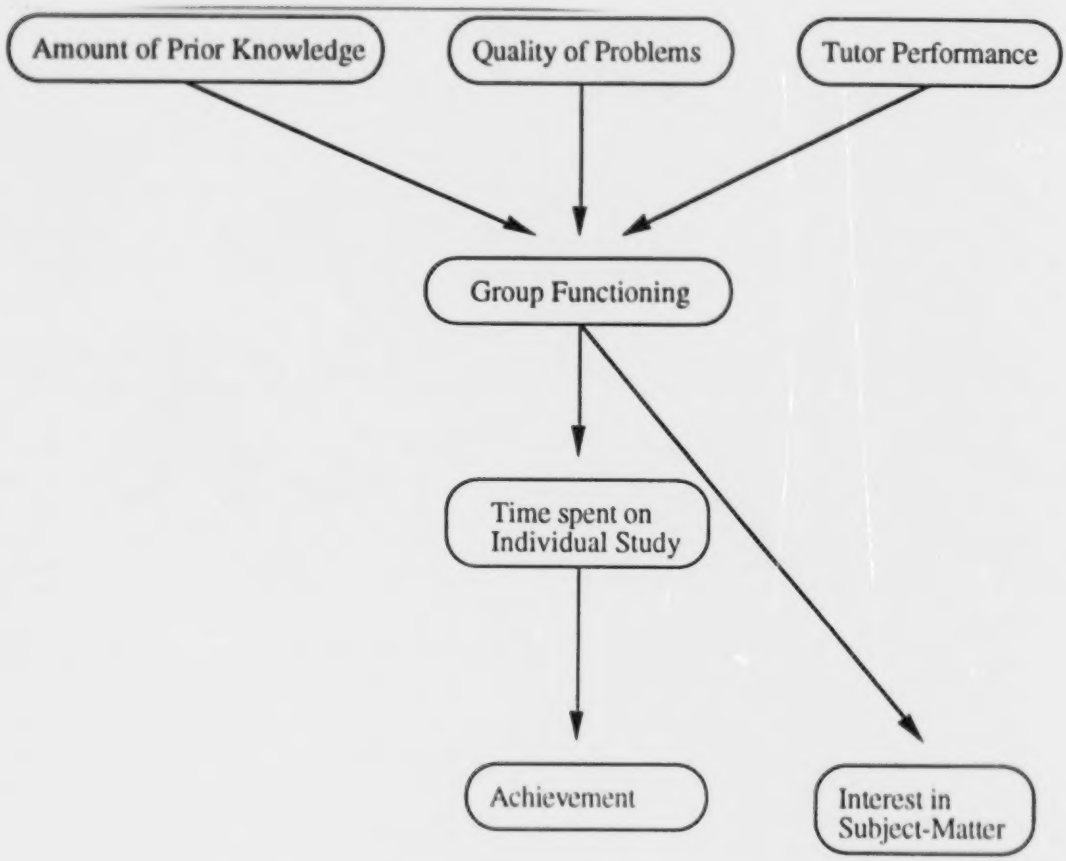

Figure 3. *Theoretical model of tutor behaviors and their relationship with other elements of problem-based learning.*

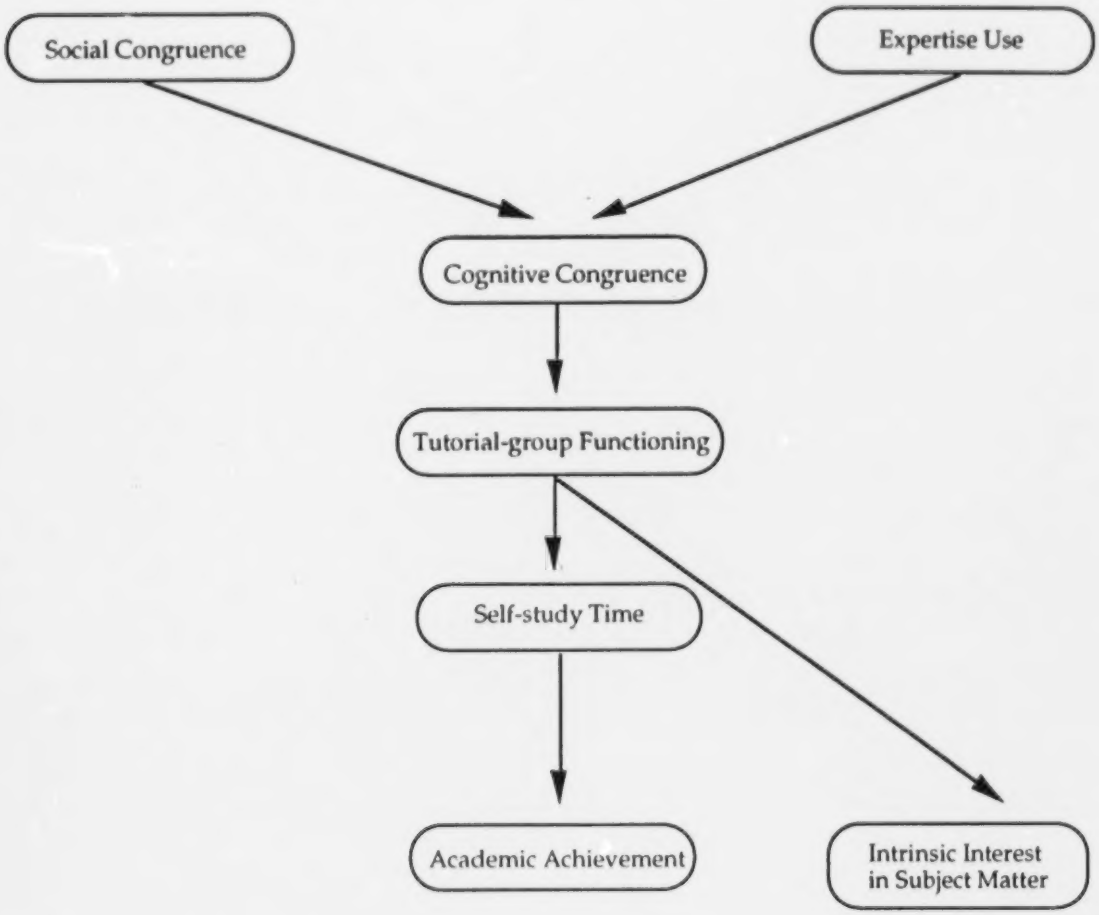

Figure 4. *Less restrictive variant of the effective tutor model.*